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A systematic evaluation of the incremental protection of broad-scale habitats at Ningaloo Reef, Western Australia

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Running head: Incremental protection of Ningaloo Reef

Abstract

Incremental increases to marine conservation areas in response to changing goals, policy, threats or new information are common practice world-wide. Ningaloo Reef, in north-western Australia, is protected by the Ningaloo Marine Park (State Waters) which was expanded incrementally in 2004 so that 34% of the park now comprises no-take sanctuary zones. To test the hypothesis that all habitats (benthic cover types) at Ningaloo are actually protected at this 34% level, a systematic conservation planning exercise was conducted using existing broad-scale habitat data (as a surrogate for marine biodiversity) and C-Plan decision-support software. Though subtidal and intertidal coral communities were found to be adequately protected, other habitats, particularly those in deeper waters seaward of the reef did not attain the 34% target. Efficient incremental additions to the sanctuary zones to allow increased representation of these under-represented habitats were explored with C-Plan. It is recommended that systematic conservation planning incorporating new biodiversity and social information (now becoming available) be undertaken for the next iteration of the Ningaloo Marine Park management plan. This analysis at Ningaloo Reef serves as a useful example of a *post-hoc* systematic approach to guide incremental expansion of existing marine protected areas in other parts of the world.

Additional key words: Conservation planning, targets, sanctuaries, marine park, management

Introduction

Incremental increases to marine protected areas in response to changing goals, policy, threats or new information are common practice world-wide. Nevertheless, the establishment of quantitative goals for biodiversity conservation based on the percentage area of a region or country that is conserved has been criticised principally for a lack of biological foundation (Svancara *et al.* 2005). Likewise, if within a particular protected area, a specific percentage is designated as no-take, this does not guarantee that all habitats within the protected area are actually protected at this level. Ubiquitous habitats may be disproportionately represented thereby placing those habitats with smaller geographical extents at risk of being under-protected.

Internationally, it has been proposed that 20-50% of marine habitats be protected in no-take areas (Gell and Roberts 2003). A recent review on quantitative methods for defining percentage area targets for habitat types in conservation planning concluded that, at present, no ideal method exists and the type of biodiversity goal and data availability should guide the choice of method (Rondinini and Chiozza 2010). Generally, either fixed targets (where all biodiversity features have the same percentage targets), or variable targets (where different biodiversity features have different percentage targets) are used in conservation planning studies (Agardy *et al.* 2003). Variable targets require site-specific empirical data such as species area curves, spatially explicit population viability analyses, heuristic principles or ecologically-based optimal reserve size determination. Targets derived from these methods range from 20-40% (Pressey *et al.* 2003; Lombard *et al.* 2007). In the absence of site-specific empirical data, fixed targets are commonly used and a baseline target of 20% is considered a starting point, until further data allow the development of variable targets (Bohnsack *et al.* 2003; Roff 2009). Defensible decisions regarding targets are a fundamental requirement of systematic conservation planning approaches (Margules and Pressey 2000) which define how much of biodiversity patterns and processes in a region should be given full protection, and then attempt to achieve this protection in a spatially efficient manner.

Australia is currently striving towards a National Representative System of Marine Protected Areas in order to conserve its biodiversity across both state and Commonwealth waters (Commonwealth of Australia 2010). In some areas, a systematic conservation planning approach has been used, for example, in the Great Barrier Reef Marine Park (Fernandez *et al.* 2005), but expansion and zonation of the Ningaloo Marine Park in north-western Australia have not proceeded with quantitative targets at the habitat level. Ningaloo is characterised by a 300 km fringing reef that is currently protected by the Ningaloo Marine Park (State Waters) (NMP-SW) in which 34% of the area is apportioned into no-take sanctuary zones (hereafter, sanctuaries) spread throughout the length of the park. In this study, a systematic conservation planning approach was used to evaluate the existing sanctuaries at Ningaloo Reef in terms of their overall contribution to protecting each of the different broad-scale habitats, defined here as areas with specific geomorphic and benthic cover attributes (*sensu* Dalleau *et al.* 2010). This study was restricted to the evaluation of pattern data only, i.e. broad-scale benthic habitats (as surrogates for overall biodiversity *sensu* Ban 2009) and their representation within the existing NMP-SW sanctuaries. A target of 34% of each habitat to be protected in sanctuaries was set because this was the overall level of no-take area achieved by the current zoning scheme. The 34% target was thus not calculated from any site-specific empirical data, and the assessment provided here tests the hypothesis that each broad-scale habitat in the NMP-SW is actually protected at this level. The objectives of this study were thus to ascertain the proportion of each broad-scale habitat protected by the zoning scheme and explore spatial options for extending protection to achieve the target of 34% for each broad-scale habitat type in sanctuaries (as opposed to merely protecting 34% of the NMP-SW).

Methods

Study area

Ningaloo Reef supports a high diversity of corals (Veron and Marsh 1988), fishes (Fox and Beckley 2005) and other biota including seasonal migrants such as whale sharks, turtles and humpback whales (Sleeman *et al.* 2007). In addition to its biodiversity value, the Ningaloo region has high social importance, particularly for its Aboriginal history, recreational opportunities and nature-based tourism.

The fringing reef was initially protected in 1987 through establishment of the NMP-SW extending offshore to the legal limit of Western Australian coastal waters (three nautical miles) of which 10% was designated as no-take sanctuary zones.

Simultaneously, the federal government of Australia proclaimed the Ningaloo Marine Park (Commonwealth Waters) in the adjacent, deeper territorial waters. In 2004, after lengthy public consultation, negotiations with stakeholders, and a complex political process, the NMP-SW was extended south to cover the full length of the reef (263 343 ha).

The NMP-SW is managed using a comprehensive plan that outlines objectives and strategies to facilitate the conservation of marine biodiversity for the period 2005-2015 (Department of Conservation and Land Management, and Marine Parks and Reserves Authority 2005). This plan incorporated a new system of zoning that incrementally built on the earlier sanctuaries and added several new ones. This resulted in 34% of the area of the NMP-SW being apportioned into 18 sanctuaries spread throughout the length of the park (Fig. 1*a*). They vary in size from the tiny Lakeside sanctuary (8 ha) to the substantial Cloates sanctuary (44 752 ha). Other zones include general use, recreation and special purpose. Special purpose zones (shore-based activities) are 100 m wide to accommodate shore-based recreational fishing and are located along the shorelines of eight of the sanctuaries. The single special purpose zone (benthic protection) is located seaward of the fringing reef in the Mandu sanctuary to accommodate recreational game-fishing for pelagic species (Fig. 1*a*).

Systematic conservation planning

Spatial data for the 11 broad-scale marine habitats at Ningaloo, derived from interpretation of aerial photographs, bathymetry and ground truthing (see Bancroft 2003), and both the 1987 and 2004 zonation schemes, were obtained in Geographic Information System (GIS) format from the Western Australian Department of Environment and Conservation (Fig. 1). Analyses were restricted to the NMP-SW but excluded the 40 m-wide coastal strip above the high water mark. Spatially explicit information on recreational fishing from a survey conducted in 1998-99 at boat ramps at Ningaloo Reef (Sumner *et al.* 2002) was also incorporated into the GIS.

The study area was divided into a series of planning units (1 km^2 or 100 ha) which could be smaller along the edges and shoreline of the study area in order to match these boundaries exactly (minimum planning unit size was 5 ha). The 18 sanctuaries were not subdivided by planning units and, consequently, each sanctuary constituted a single planning unit. The 2281 final planning units were overlaid on the habitat map in the GIS in order to determine the amount of each habitat in each planning unit. As described above, a target of 34% of each broad-scale habitat to be protected in sanctuaries was set.

The systematic conservation planning software, C-Plan (Pressey 1999) was used to calculate the percentage of each habitat type in each of the zone types, and thereafter to identify those planning units that would be required as sanctuaries in cases where a habitat did not have 34% of its area already in a sanctuary. C-Plan is a decision-support tool which, together with a GIS, maps the options for achieving an explicit conservation goal in a region; allows users to decide which sites should be placed under some form of conservation management; accepts and displays these decisions, and then lays out the resulting new pattern of options. It does this by calculating the irreplaceability of each planning unit. Irreplaceability is the likelihood that the planning unit will be needed to meet the conservation target (Ferrier *et al.* 2000). The user can then design a notional reserve system by expanding existing sanctuaries or creating new ones with planning units of high irreplaceability value. At Ningaloo, the target was not met for some habitats and, using C-Plan, spatial options for attaining the target were explored by building incrementally onto existing sanctuary areas, while avoiding areas with high boat-based recreational fishing effort.

Results and discussion

Broad-scale habitat representation in zones

The fringing reef with its subtidal and intertidal coral communities comprises 19% of the total area of the NMP-SW (Fig. 2). Low relief, subtidal reef seaward of the fringing reef is the dominant habitat type (44%) and subtidal lagoonal reef comprises 10% of the park. Deep-water mixed filter feeding and soft bottom communities comprise 22% of the area, and shoreline reef, sand, macro-algal beds and a small area of mangals with associated mudflat and saltmarsh constitute the remaining 5%.

Greater than 20% of the total area of each broad-scale habitat is protected in the 2004 sanctuaries (Fig. 2), considerably improving on the 1987 zonation scheme. Both subtidal and intertidal coral reef communities are well represented and, as with macro-algae, sand and subtidal lagoonal reef, each attains the target of 34%. The small area associated with mangals is entirely encompassed by the Mangrove sanctuary (Fig.1*a*).

However, although from 1987 to 2004 there were huge improvements in the amount of subtidal reef (seaward) and deep water mixed filter feeding and soft bottom communities in sanctuaries (from 0-23% and 0-24%, respectively), both these habitats, and shoreline reef, are still represented at less than the 34% target.

Subtidal reef (seaward) is proportionally the least protected habitat in the NMP-SW (Fig. 2). The largest areas of this low coral cover habitat occur in the northern and southern portions of the park where the fringing reef abuts the shoreline and lagoonal areas are scarce (Fig. 1*b*). Various options for target achievement were explored in the south because of the known high intensity of boat-based recreational fishing in the north (Sumner *et al.* 2002). For example, extending all three sanctuaries in the south (Cape Farquhar, Gnarraloo, 3 Mile) to the seaward boundary of the NMP-SW did not meet the target but if, in addition to these extensions, the entire area between 3 Mile sanctuary and Red Bluff was upgraded to sanctuary level protection, the target could be met (Fig. 3).

Deep water mixed filter feeder and soft bottom communities dominate in the north of the park (Point Cloates to North West Cape) because of the narrow and steep nature of the continental shelf (Fig. 1). Achievement of the target for this habitat would require extending sanctuaries offshore. For example, widening the Winderabandi sanctuary seaward to the NMP-SW boundary or changing the designation of Mandu special purpose zone (benthic protection) to sanctuary both provided efficient options to achieve the target (Fig. 3). Note that this Mandu special purpose zone was a compromise solution allowing both protection and fishing although such partial fishing closures have been shown to be ineffective as conservation tools (Denny and Babcock 2004).

The reason that shoreline reef does not meet the 34% target is largely a result of the inclusion of much of this limited habitat in recreation or special purpose (shore-based activities) zones. Instead of creating new, narrow sanctuaries to accommodate this geographically specific habitat, the most efficient way to increase its protection would be to rezone special purpose zones (shore-based activities) inshore of sanctuaries. If, for example, the special purpose zones inshore at Winderabandi or Osprey were designated as sanctuary, the target for shoreline reef conservation could be achieved (Fig. 3).

Incremental increase in protection

The incremental increase in the proportional area of sanctuaries in the NMP-SW was similar to that achieved by expansion of the Great Barrier Reef Marine Park (Fernandez *et al.* 2005) although, at Ningaloo, a formal systematic conservation planning approach was not used. Stewart *et al.* (2007) have cautioned that there is a loss of efficiency when a reserve system that was not initially systematically designed is incrementally increased, and this may be evident at Ningaloo. However, if conservation targets are increased in response to changing goals, policy, threats or new information, this will probably be the case for the vast majority of older, existing marine protected areas implemented before systematic conservation planning methods became widely used. This analysis at Ningaloo Reef could thus serve as a useful example of a *post hoc* systematic approach to guide conservation implementation and would be recommended for future revisions of the management plan.

Improving input data for conservation planning

Although the NMP-SW is essentially located in one meso-scale bioregion that extends from North West Cape to Red Bluff (Commonwealth of Australia 2006), improving the spatial and thematic resolution of biodiversity data may reveal further gaps in the protection of habitats by the current zoning scheme. Greater resolution may also actually show subtle changes in *beta* diversity associated with gradients in the physical environment over three degrees of latitude. Indeed, a bioregional subdivision of habitats in the Great Barrier Reef Marine Park was necessary to achieve adequate representation in the recent re-zoning of this very large, iconic, marine protected area (Fernandez *et al.* 2005).

Information on use of marine resources is essential for efficient planning of marine protected areas (Stewart *et al.* 2003), and is especially so at Ningaloo Reef where recreational pursuits and nature-based tourism are widely renowned. The recreational fishery survey at the major boat ramps in the region clearly indicated the high usage in proximity to the Exmouth, Tantabiddi and Coral Bay access points (Sumner *et al.* 2002). In contrast, diffuse access to the lagoon by anglers using small, beach-launched boats or fishing from the shore, particularly by campers who frequent the Cape Range National Park and the coastline of pastoral stations adjacent to the NMP-SW, was not well quantified or spatially explicit (Sumner *et al.* 2002). It is likely that the incremental increase in the area of sanctuaries subsequent to the 1998-99 survey has resulted in some displaced fishing effort and relocation to areas outside of sanctuaries.

Successful implementation of systematic conservation planning outcomes relies on building high resolution human use data into the planning framework as a "cost" to the conservation of biodiversity (Stewart and Possingham 2005; Possingham *et al.* 2006; Ban *et al.* 2009; Selkoe *et al.* 2009; Trebilco *et al.* 2011). This allows spatial conservation initiatives in areas of least conflict thereby maximising their likelihood of success. Further, the importance of high resolution social and biodiversity data in the development of effective conservation plans has been highlighted in the operational framework for implementing conservation action developed by Knight *et al.* (2006).

Improvements to the resolution of both biodiversity and marine resource usage data sets at Ningaloo Reef are nearing completion through numerous concurrent research projects being conducted by Australian state government departments, federal agencies and universities. For example, spatial information on intensity and distribution of boating and coastal recreation activities in the NMP-SW has just been published (e.g. aerial survey data from Smallwood *et al.* 2011).

In conclusion, our assessment showed that although 34% of the NMP-SW area is protected in sanctuaries, not all broad-scale habitats are protected at this level. The C-plan exercise showed how more representative habitat protection could be achieved by extending existing sanctuaries in a spatially efficient manner. The next iteration of the NMP-SW management plan (scheduled for 2015) provides an excellent opportunity to use a systematic conservation planning approach incorporating the new fine-scale biodiversity and social information, with the possibility of using variable targets for different habitats if site-specific empirical data become available. Further, embedding the conservation planning process in an operational framework (*sensu* Knight *et al.* 2006) would also allow progress along the conservation continuum from mere habitat representation to actual persistence of Ningaloo Reef.

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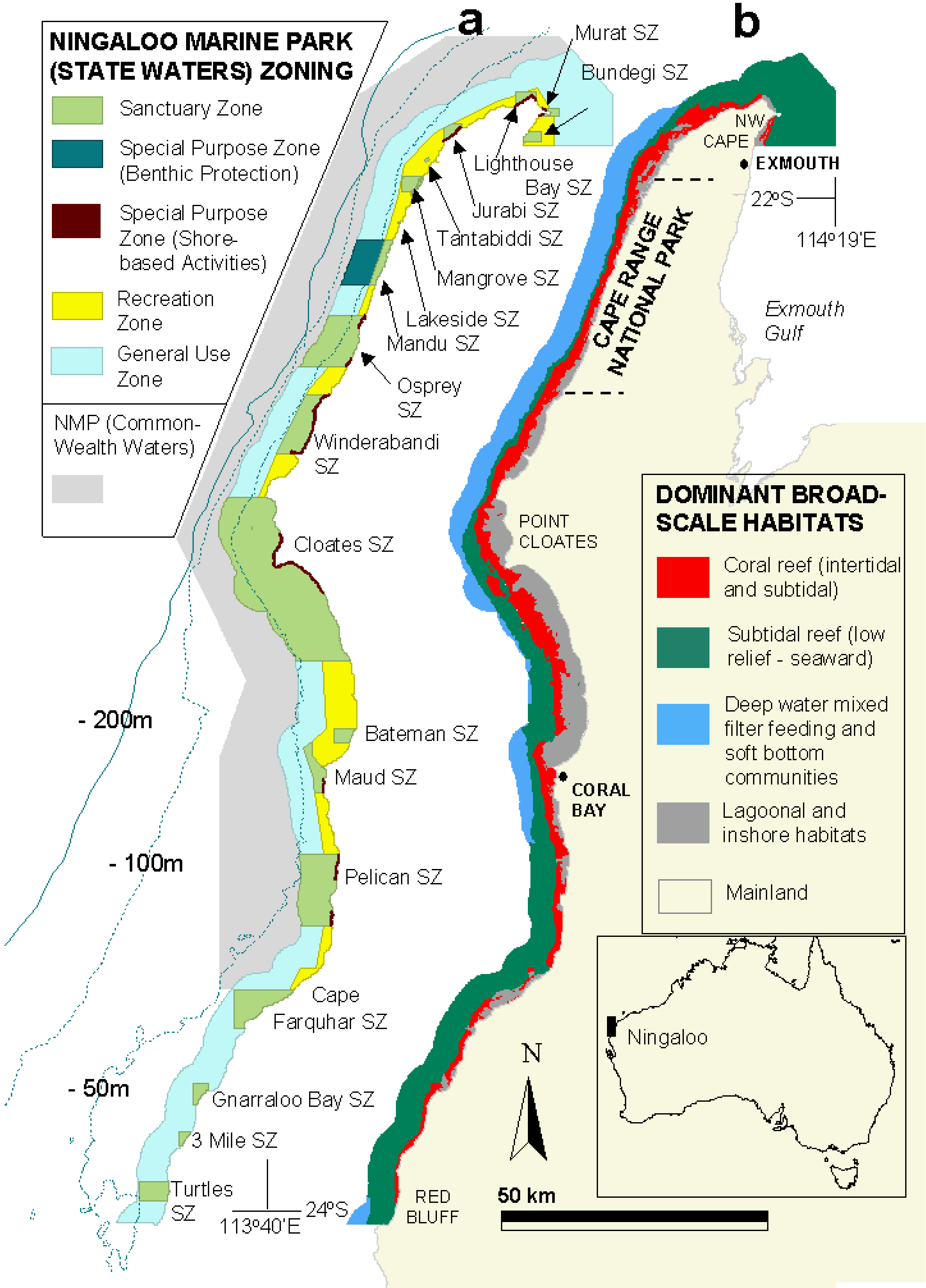
Figure legends

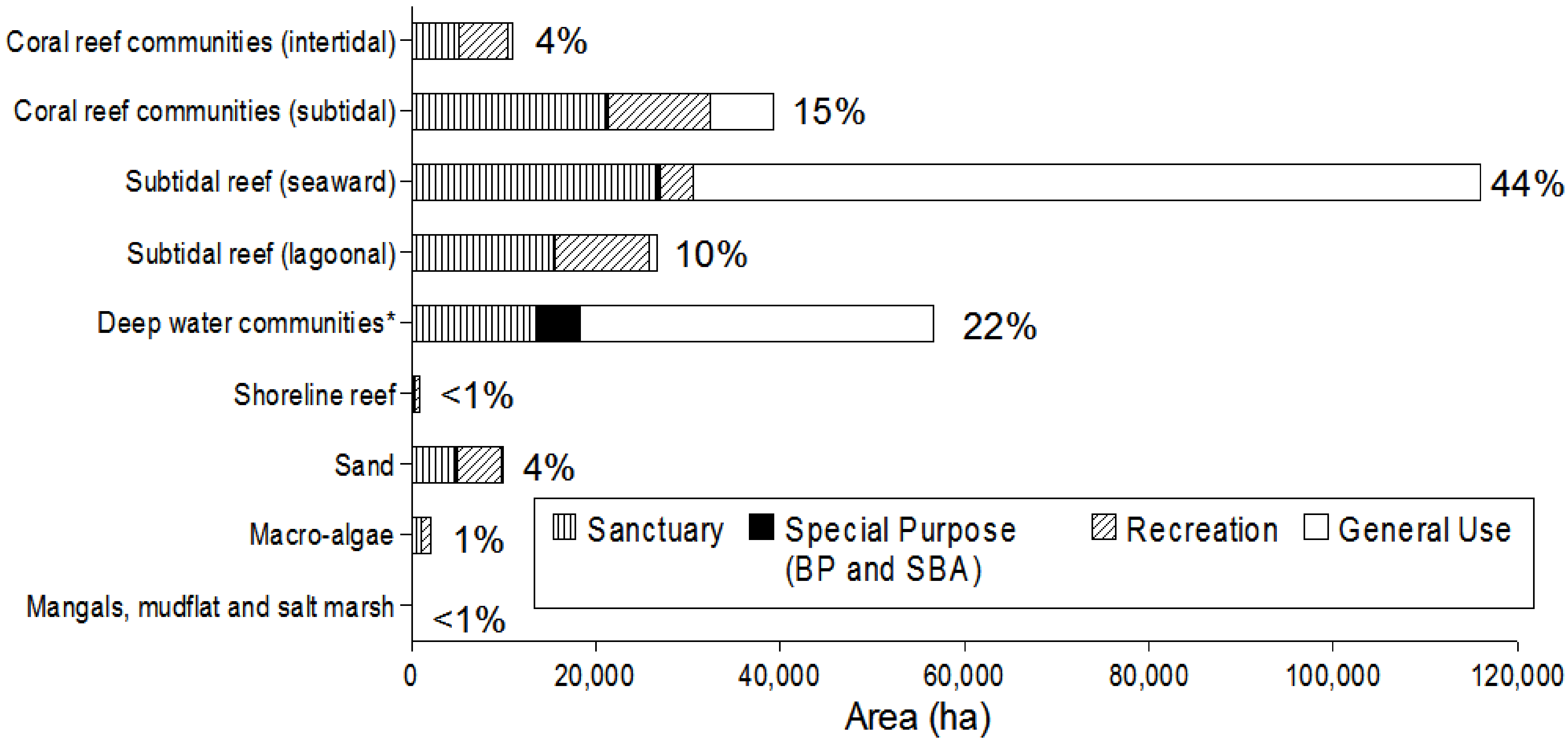
Fig. 1. Ningaloo Marine Park (State Waters) showing (a) the 2004 zoning scheme and (b) dominant broad-scale benthic habitats. All information was summarised from spatial data obtained from the Western Australian Department of Environment and Conservation.

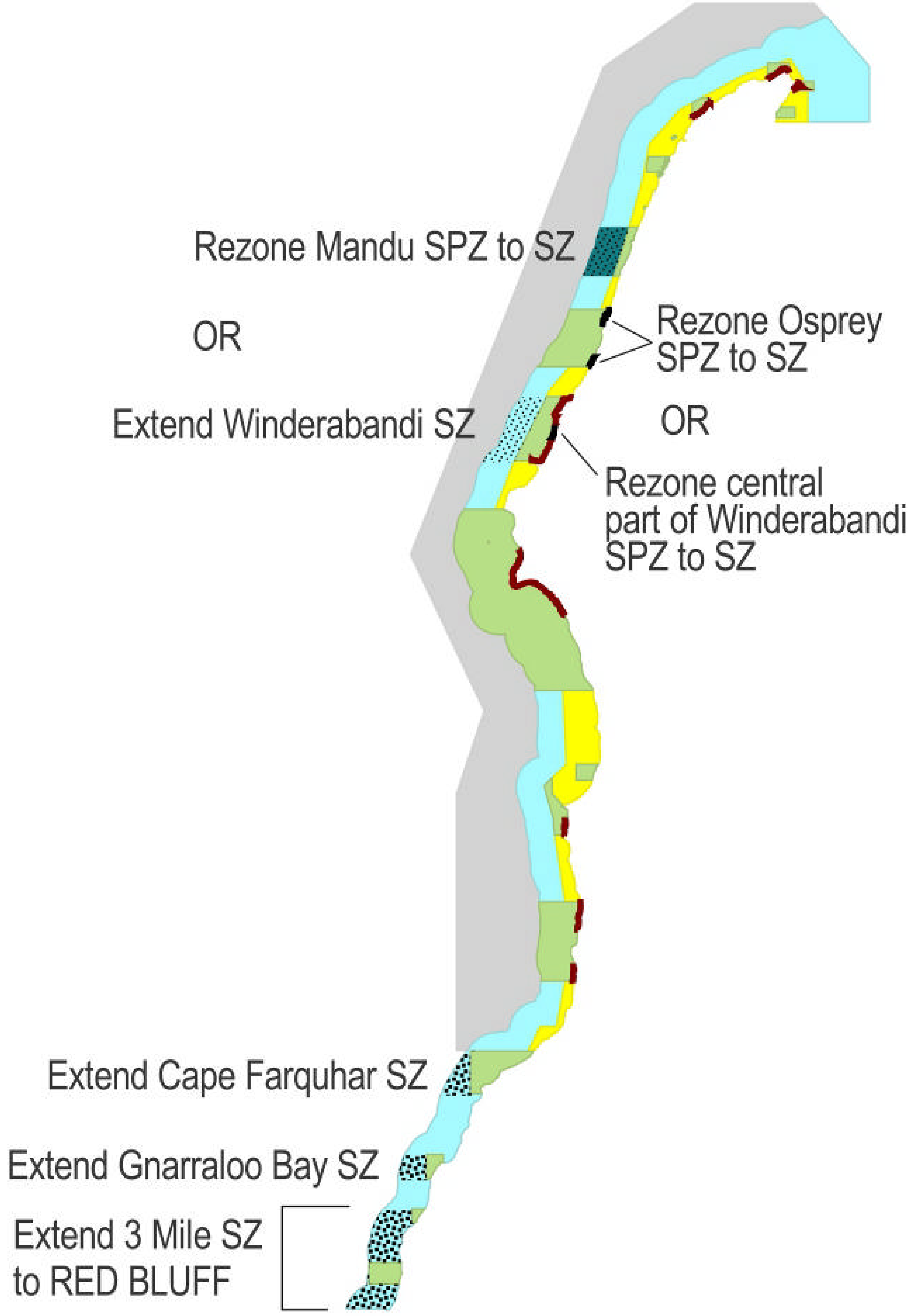
Fig. 2. Total area (ha) of broad-scale benthic habitats in the Ningaloo Marine Park (State Waters). The percent values at the end of each bar refer to the contribution of each habitat to the park's total area. In addition, the proportion of each habitat in the different zones is shown by the shading within each bar. * Deep water mixed filter feeder and soft bottom communities.

Fig. 3. Ningaloo Marine Park (State Waters) showing the 2004 zoning scheme (explained in Fig. 1) and possible extensions (black stipple shading) to existing sanctuaries to meet 34% targets for all broad-scale habitats (determined using C-Plan).



a
b
NINGALOO MARINE PARK (STATE WATERS) ZONING
Sanctuary Zone
Special Purpose Zone (Benthic Protection)
Special Purpose Zone (Shore-based Activities)
Recreation Zone
General Use Zone
NMP (Common-Wealth Waters)
Murat SZ
Bundegi SZ
Lighthouse Bay SZ
Jurabi SZ
Tantabiddi SZ
Mangrove SZ
Lakeside SZ
Mandu SZ
Osprey SZ
Winderabandi SZ
Cloates SZ
Bateman SZ
Maud SZ
Pelican SZ
Cape Farquhar SZ
Gnarraloo Bay SZ
3 Mile SZ
Turtles SZ
- 200m
- 100m
- 50m
24°S
113°40'E
NW CAPE
EXMOUTH
22°S
114°19'E
CAPE RANGE NATIONAL PARK
Exmouth Gulf
POINT CLOATES
CORAL BAY
RED BLUFF
DOMINANT BROAD-SCALE HABITATS
Coral reef (intertidal and subtidal)
Subtidal reef (low relief - seaward)
Deep water mixed filter feeding and soft bottom communities
Lagoonal and inshore habitats
Mainland
Ningaloo
N
50 km


Coral reef communities (intertidal)
Coral reef communities (subtidal)
Subtidal reef (seaward)
Subtidal reef (lagoonal)
Deep water communities*
Shoreline reef
Sand
Macro-algae
Mangals, mudflat and salt marsh
4%
15%
44%
10%
22%
<1%
4%
1%
<1%
Sanctuary
Special Purpose (BP and SBA)
Recreation
General Use
0
20,000
40,000
60,000
80,000
100,000
120,000
Area (ha)



Rezone Mandu SPZ to SZ
OR
Extend Winderabandi SZ
Rezone Osprey SPZ to SZ
OR
Rezone central part of Winderabandi SPZ to SZ
Extend Cape Farquhar SZ
Extend Gnarraloo Bay SZ
Extend 3 Mile SZ to RED BLUFF